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EFFECT OF SLOW AND FAST PRANAYAMS ON REACTION TIME AND CARDIORESPIRATORY VARIABLES

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Abstract : We planned to undertake a comparative study of the effect of short term (three weeks) training in savitri (slow breathing) and bhastrika (fast breathing) pranayams on respiratory pressures and endurance, reaction time, blood pressure, heart rate, rate-pressure product and double product. Thirty student volunteers were divided into two groups of fifteen each. Group I was given training in savitri pranayam that involves slow, rhythmic, and deep breathing. Group II was given training in bhastrika pranayam, which is bellows-type rapid and deep breathing. Parameters three ween traininperiod A. saviten
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INTRODUCTION

Yogic techniques produce remarkable physiological changes and have sound scientific basis (1, 2, 3). Pranayam, the fourth step of ashtang yoga is an important component of yoga training. Earlier reports from our laboratories have demonstrated improved reaction time (RT) and respiratory pressures following twelve weeks yoga training that included asans as well as pranayams (2). Malathi et al (4) also have demonstrated a significant reduction in visual reaction time (VRT) and auditory reaction time (ART) following six weeks of yoga training. There are a number of reports on the effect of long-term yoga training on pulmonary functions (5, 6, 7, 8, 9). However, to the best of our knowledge, the effect of short-term pranayam training on RT and pulmonary function has not been studied so far. Moreover, literature is deficient on the effect of yoga training on respiratory pressures i.e., maximum expiratory pressure

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(MEP) and maximum inspiratory pressure (MIP). In yoga tradition, it is taught that different pranayams have different effects. Raghuraj et al (10) have studied the acute effect of fast and slow pranayams on heart rate variability while Telles and Desiraju (11) have demonstrated the heart rate changes during the performance of different pranayams. However, there are only a few comparative studies on the effects of slow and fast pranayam training. Hence, we planned to undertake a comparative study of the effect of short-term (three weeks) training in slow and fast pranayams on VRT, ART, MEP and MIP. We also planned to study their effects on blood pressure (BP), heart rate (HR), double product (Do P) and rate-pressure product (RPP) since RPP is an easily measurable index of myocardial oxygen consumption and load on the heart (12). Thus the objective of the present study was to do a comparative study of the effect of short term (three weeks) slow and fast pranayam training on RT and cardiorespiratory variables.

MATERIALS AND METHODS

Subjects and training :

The present study was conducted on thirty healthy volunteers of either gender. Their age was 15–18 y, weight 40–60 kg and height 155–170 cm. They were non smokers and were not on any medication prior to this study. Clearance was obtained from Institute Ethics Committee. The subjects were familiarized with the aims and objectives of the study as well as laboratory environment and written consent was obtained from their parents. They were divided into two groups of fifteen each. Group I was taught slow breathing savitri pranayam while group II was taught fast breathing bhastrika pranayam. The techniques of these pranayams are given elsewhere (13, 14). Briefly, savitri pranayam is a slow, deep and rhythmic breathing, each cycle having a ratio of 2:1:2:1 between inspiration (purak), held-in (kumbak), expiration (rechak), and held out (shunyak) phases of the respiratory cycle. Bhastrika pranayam is a bellows-type fast breathing involving forceful contraction of inspiratory as well as expiratory muscles. The subjects were given pranayam training and practised the same under the guidance of a qualified yoga teacher. Practice sessions were conducted five days a week during the morning hours for thirty minutes for a total duration of three weeks. As the period of training was only three weeks and as the subjects formed their own control, a separate control group was not incorporated.

Parameters : MEP was determined by asking the subject to blow against a mercury column after taking a full breath and to maintain the column at the maximum possible level for about two seconds. MIP was determined by asking the subject to perform maximum inspiratory effort against mercury column after breathing out fully. The maximum inspiratory pressure that could be maintained for about two seconds was noted. Respiratory endurance was determined by asking the subjects to take in a full breath and blow against the mercury column up to a pressure of 20 mm Hg. Time in seconds that the subject could maintain the mercury level at 20 mm Hg was noted. We determined respiratory endurance at 20 mm Hg instead of the usual 40 mm Hg since some of our subjects were unable to raise and/or maintain the mercury level at 40 mm Hg. Care was taken to prevent leak through mouthpiece by securing the lips with fingers of the subject. A mouthpiece made of glass helped us to observe that the subjects performed the maneuver properly. Breath holding time (BHT) was determined by noting the maximum time in seconds that the subject could hold his/her breath after breathing in fully. For MEP, MIP, respiratory endurance and BHT, a minimum of three trials were given with rest period of three minutes between the trials and the highest of three similar best performances was taken for statistical analysis (2). BP and HR were measured using a portable non-invasive BP monitor (Omron Inc., Japan). RPP was calculated as SP × HR × 10^{-2} where SP is systolic pressure and the value thus obtained was expressed as mm Hg. beats per minute. 10^{-2}. Similarly, Do P was calculated as MP × HR where MP is mean pressure and it was expressed in mm Hg. beats per minute.

VRT and ART were measured with the subject sitting comfortable in a chair. To avoid the effect of lateralized stimulus, visual and auditory signals were given from the front of the subject who was instructed to use his dominant hand while responding to the signal (2). RT was measured on a fast moving paper using a kymograph by asking the subject to open as quickly as he could, a tap key that was kept in series with a magnetic time marker and connected alternatively to a light or sound source. Stimulus applied by completing the circuit was marked by downward deflection of the recording.

Subject's response by breaking the circuit was marked by upward deflection on the recording. RT was calculated as the time between these two deflections. At least ten trials were recorded for each subject and mean of three similar observations was taken as a single value for statistical analysis (2).

Out of fifteen subjects of group I, seven dropped out and the number of subjects who completed the study was eight. From group II, three subjects dropped out and twelve completed the study. Pre- and post-training recordings of all the parameters were made in morning, about two hours after a light breakfast. A few days before actual measurements, the subjects were familiarized with the procedures and mock testing was done until we were satisfied that they understood and performed the tasks correctly.

Statistical analysis: The values obtained before and after the training period were compared using Student's paired *t*-test. Difference of the values between the two groups was compared using Student's unpaired *t*-test. A p value of less than 0.05 was accepted as indicating significant difference between the compared values.

RESULTS

The results are given in Table I. All the values of the two groups were comparable before training period. In savitri pranayam group there was significant ($P<0.05$) increase in MEP, MIP and respiratory endurance after three weeks of the training period. In bhastrika pranayam group, there was highly significant ($P<0.01$) increase in respiratory endurance and an insignificant increase in MEP and MIP. BHT increased significantly ($P<0.05$) in the bhastrika pranayam group and insignificantly in

TABLE I : Effect of 3 weeks training in savitri and bhastrika pranayams on maximum expiratory pressure (MEP), maximum inspiratory pressure (MIP), respiratory endurance, breath holding time (BHT), visual reaction time (VRT), auditory reaction time (ART), systolic pressure (SP), diastolic pressure (DP), mean pressure (MP), heart rate (HR), rate-pressure product (RPP) and double product (Do P).

	Savitri Pranayam		*Bhastrika Pranayam*	
	Before	*After*	*Before*	*After*
MEP (mm Hg)	55.00±4.72	70.88±6.77*	58.42±5.62	60.00±7.07
MIP (mm Hg)	45.75±4.27	65.25±8.13*	56.50±6.93	60.00±7.88
Respiratory endurance (s)	22.38±2.86	30.38±4.01*	20.33±3.11	27.75±2.70**
BHT (s)	50.75±8.73	58.50±3.70	51.36±10.42	64.00±11.55*
VRT (ms)	196.20±8.53	179.61±14.71	179.92±5.62	178.75±10.18
ART (ms)	141.85±6.34	127.94±6.7	135.75±5.80	115.94±8.97
SP (mm Hg)	100.50±3.57	98.00±3.62	100.58±3.52	102.08±3.75
DP (mm Hg)	64.13±1.73	61.00±2.14*	60.00±2.72	64.33±3.47
MP (mm Hg)	76.25±2.05	73.31±2.40	73.53±2.53	77.84±3.01
HR (bpm)	72.00±3.4	68.00±2.99	72.92±2.14	79.33±3.11^{+}
RPP (mm Hg. bpm.10^{-2})	71.79±2.53	66.24±2.73	73.51±3.57	79.87±4.63^{+}
Do P (mm Hg. bpm)	5457.13±190.61	4968.88±226.63	5368.61±260.04	6230.79±460.28*$^{+}$

Values are expressed as mean±SEM. *P<0.05, **P<0.01 by paired *t*-test. $^{+}$P<0.05 by unpaired *t*-test.

savitri pranayam group. Although there was a decrease in VRT and ART in both the groups, this decrease was statistically insignificant. Following three weeks of training, HR, RPP, and Do P decreased in savitri pranayam group and increased in bhastrika pranayam group and the difference between the two groups was statistically significant (P<0.05) when compared by students unpaired *t*-test. There was also a significant decrease (P<0.05) in diastolic pressure (DP) in savitri pranayam group following three weeks of training.

DISCUSSION

Respiratory muscles are vital and evaluation of their performance is important. Maximum expiratory and inspiratory pressures reflect the strength of muscles of expiration and inspiration respectively. They are sensitive, reproducible and can be altered in patients even when there is little abnormality in other indices of pulmonary function such as forced vital capacity (15). Three weeks training in savitri pranayam produced an appreciable and significant increase in MEP and MIP (28.9% and 42.6% respectively). On the other hand, training in bhastrika pranayam produced a statistically insignificant increase in these parameters. Respiratory endurance increased appreciably after savitri as well as bhastrika pranayam training (35.7% and 36.5% respectively). In an earlier work, we have reported that yoga training produces a significant increase in MEP, MIP as well as respiratory endurance (2). The pre-training values of respiratory pressures and endurance are lower in the present study as compared to earlier studies (2, 15). This might be due to the fact that our subjects had less muscle mass since they had lower body weight and were younger in age as compared to our earlier study. Respiratory pressures are known to be volume-dependent (15). We measured MEP after the subject took in a full breath and MIP after breathing out fully since Chen & Kuo (16) have reported that inspiratory muscle strength is higher at residual volume while expiratory muscle strength is higher near total lung capacity. Yoga training is known to improve pulmonary function. The marked increase in respiratory pressures and endurance in our group I subjects shows that savitri pranayam is an effective way to develop respiratory musculature. Savitri and bhastrika pranayams involve deep inspiratory as well as expiratory efforts and thus exercise inspiratory as well as expiratory muscles. The significant increase in respiratory endurance in both the groups is consistent with the observations of Chen & Kuo (16) that physical activity increases respiratory muscle endurance. Since MEP. MIP and respiratory endurance are easy to perform, sensitive and reproducible (16). We recommend that measurement of respiratory muscle strength and endurance should be done routinely in studies determining the effectiveness of yoga training, studying and monitoring the effect of treatment in patients with diseases associated with muscle weakness.

In group II subjects, training in bhastrika pranayam produced a statistically significant increase in BHT. In savitri pranayam group, although the increase in BHT was appreciable (15.3%), it was not statistically significant. This might be due to small sample size (n=8) of group I. Our results are similar to the findings of Makwana et al (7) who have reported that yoga training produces a significant increase in BHT. Nayar et al (17) also have reported a highly significant increase in BHT after yoga training. They have suggested that pranayam be used as short period of conscious control of rate and depth of breathing as health promoting exercise.

In both the groups, ART was shorter than VRT and this is consistent with the results of our previous study (2). This is in contrast to the findings of Shenvi and Balasubramanian (18) who have reported that VRT is shorter than ART in boys as well as girls. After pranayam training, there was a reduction in VRT as well as ART in both the groups. Although the decrease was appreciable, it was statistically insignificant and this may be due to small sample size. It is also probable that with longer duration of pranayam training there may be a further and statistically significant decrease in VRT and ART in both the groups. RT is an indirect index of the processing ability of central nervous system and a simple and inexpensive means for determining sensorimotor performance (2). Shortening of VRT as well as ART after pranayam training signifies greater arousal, improved concentration and faster responsiveness.

It is well known that yoga training decreases HR and BP (1). In the present study, savitri pranayam training resulted in a statistically insignificant decrease in resting HR and SP and a statistically significant ($P<0.05$) reduction in DP. It may be noticed that the duration of training in the present study was short (3 weeks). It is likely that with longer training, BP and HR may show further and significant decrease. Savitri pranayam, which is a slow and rhythmic breathing, has been found to produce deep psychosomatic relaxation and decrease in oxygen consumption (1). A reduction in BP and HR by savitri pranayam indicates a decrease in sympathetic activity. Bhastrika pranayam involves forceful contraction of respiratory muscles (including abdominal muscles). The increase in HR, RPP and Do P in bhastrika pranayam group suggests an increase in sympathetic activity. In this connection, it is interesting to know that Raghuraj et al (10) have reported that nadishuddi (slow breathing through alternate nostrils) reduces sympathetic activity while kapalabhati (breathing at high frequency with forceful abdominal contractions) produces sympathetic stimulation. In the present study, RPP and Do P decreased in savitri pranayam group and increased in bhastrika pranayam group. RPP is an index of myocardial oxygen consumption and work done and indicates load on heart (12). Hence the present study demonstrates that savitri pranayam decreases while bhastrika pranayam increases load on heart.

In conclusion, the present study shows that savitri (slow breathing) and bhastrika (fast breathing) pranayams have different physiological effects. While training in slow breathing pranayam reduces HR, RPP, and Do P, fast breathing pranayam produces an increase in these parameters. Further, pranayam training increases respiratory muscle strength and endurance.

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